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### THE IMMINENT DISAPPEARANCE OF THE APLOMADO FALCON FROM THE CHIHUAHUAN DESERT

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The Northern Aplomado Falcon (*Falco femoralis septentrionalis*) is a savannah-dwelling raptor whose range centers in Latin America, and whose distribution once extended northward into coastal Texas, western Texas, southern New Mexico, and southeastern Arizona (Keddy-Hector 2000, Fig. 1). The species had virtually disappeared from the United States by the 1930s, primarily as a result of habitat destruction by farming and livestock grazing (Hector 1981). A fairly robust population breeds in tropical savannahs from Veracruz, Mexico, southward into Central America, whereas only two small populations occur north of that region. One consists of about 30 pairs restored in recent years to coastal Texas by The Peregrine Fund through captive breeding and release (Hunt et al. 2013). The other occurs in the grasslands of central Chihuahua, Mexico (Macías-Duarte et al. 2004) and is the subject of this paper.

This native population in Chihuahua, discovered in the 1990s, is believed to be the last remnant of the desert-

dwelling Aplomado Falcons that formerly extended into the Chihuahuan Desert region of the United States (Montoya 1995, Montoya et al. 1997, Macías-Duarte et al. 2004). Indeed, there are occasional sightings of wild Aplomado Falcons in nearby southern New Mexico (Young et al. 2004), with several cases of successful nesting just inside its border (Meyer and Williams 2005). Even so, a decade-long attempt at reintroduction of captive-bred falcons in New Mexico and west Texas by The Peregrine Fund produced no self-sustaining population (Hunt et al. 2013). We here report the current status of the wild population in Chihuahua and describe the factors that are undermining its persistence.

Nest-territory monitoring, which began soon after the discovery of the Chihuahua population, revealed a strong dependence of reproductive success and nest initiation date upon annual variation in the abundance of grassland birds (falcon prey), and they, in turn, upon precipitation (Montoya et al. 1997, Macías-Duarte et al. 2004, Hunt et al. 2013). Trends in nesting success suggested that this population was declining by the early 2000s. Overall mean productivity during that period (0.83 fledglings per mated pair per year) appeared too low to sustain a stable population (Macías-Duarte 2002). Droughts, coupled with overgrazing by cattle and falcons drowning in livestock watering tanks, were

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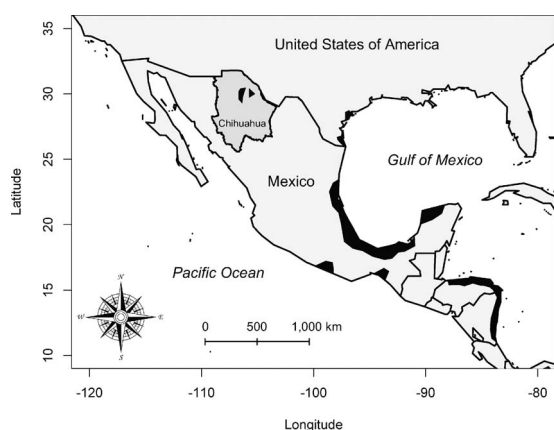


Figure 1. Breeding distribution of the Northern Aplomado Falcon (black areas). The Sueco (west) and Tinaja Verde (east) study areas are shown within the state of Chihuahua in northern Mexico. Map redrawn from Keddy-Hector (2000) and Hunt et al. (2013).

hypothesized as primary causes of population decline. A new threat appeared in 2006 when the creation and development of agricultural colonies began an extensive conversion of occupied falcon habitat into almost 70,000 ha of irrigated farmland (Macías-Duarte et al. 2009, Pool et al. 2014). Besides direct destruction of habitat, farming also brought other potentially adverse factors, including pesticides and an extensive network of roads and electric lines to the region. All things considered, the long-term viability of Aplomado Falcon populations in the Chihuahuan Desert appears increasingly uncertain. Our objective in this report is to document the trend of the Aplomado Falcon population in Chihuahua, under the simultaneous effects of drought and breeding habitat loss and deterioration. We also consider management options for preventing extirpation.

#### METHODS

We conducted Aplomado Falcon surveys as described in Macías-Duarte et al. (2004) in two study areas, Sueco and Tinaja Verde (Fig. 1) during 2003–2015. The areas differ somewhat in ecological conditions (Macías-Duarte et al. 2004) and the extent of breeding habitat destruction. Falcon habitat at Sueco is hotter, drier, flatter, and lower in elevation than that at Tinaja Verde; falcon habitat loss by farming has occurred only at Sueco.

We defined a breeding territory (territory hereafter) as an area that contained at least one nest from 1997–2014 within the range of a mated pair. We defined an occupied territory as one containing a mated pair, an active territory as one where eggs were laid, and a successful territory as one containing large young. Our approach in monitoring falcon reproduction was to find and monitor as many occupied and active territories as possible within the two study areas. By 2002, Macías-Duarte et al. (2004) had identified and monitored 24 territories at Sueco and 11 at Tinaja Verde, and we

did not continue searching for more in this study. We defined an “extant” territory as one occupied by a pair at least once since 2000 and still intact; i.e., not yet converted to cropland. We began each annual survey prior to incubation and periodically observed pairs until fledgling or failure was confirmed. Prior to 2012, we visited each occupied and previously occupied territory at least twice per month from February to June. We surveyed only once per month from 2012–2014. In some cases, territories noted as unoccupied may have contained undetected pairs. In 2015, we surveyed each extant territory once during the entire breeding season, except when we detected a falcon pair, in which case, we monitored it once per month to determine nest success.

#### RESULTS

The total number of known occupied and active territories steeply declined after 2006 in both Sueco and Tinaja Verde (Fig. 2). The number of occupied territories declined from 31 in 2000 (Macías-Duarte et al. 2004) to three in 2014. Likewise, the number of active territories fell from 24 in 2000 to two in 2014. This decline in territory occupancy was due to both conversion to cropland at Sueco by farming (Fig. 2, 3) and failure of Aplomado Falcons to occupy 19 extant territories, particularly in Tinaja Verde. Conversion of desert grasslands to farmland had not reached the Tinaja Verde study area in 2014 (Fig. 3), and yet we detected only one pair among the 11 territories available there during that breeding season. In 2015, a year of increased precipitation, we found four active territories in Sueco and one in Tinaja Verde, respectively, from which three pairs raised at least two fledglings overall.

#### DISCUSSION

The observed trends in territory occupancy through the study period suggest a decline, almost to extirpation, of the only known breeding population of Aplomado Falcons in the Chihuahuan Desert. The actual extent of population distribution is unknown because there is no current assessment of the range and quality of open grassland habitat in the region. However, based on trends in monitoring and sightings of pairs and individual falcons outside our study areas, we estimate that there may be as few as 10 pairs remaining in central Chihuahua, which may have considerable consequences for recruitment. Consider, for example, that the 2014 surveys in our study revealed only two nests, collectively producing only one juvenile, as compared with 24 breeding pairs producing 33 juveniles in 2000 (Macías-Duarte 2002). If the factors mediating this decline operate in a regional context—and there is little reason to think otherwise—then the extirpation of the central Chihuahua population appears imminent. In this regard, there was scarce evidence of the presence of Aplomado Falcons in other regions of Chihuahua (although occasional sightings of adults occur outside our study areas), nor in the grasslands of Durango and Coahuila. Habitat protection and enhancement at Sueco and Tinaja Verde are thus important strategies for survival, and the need is urgent.

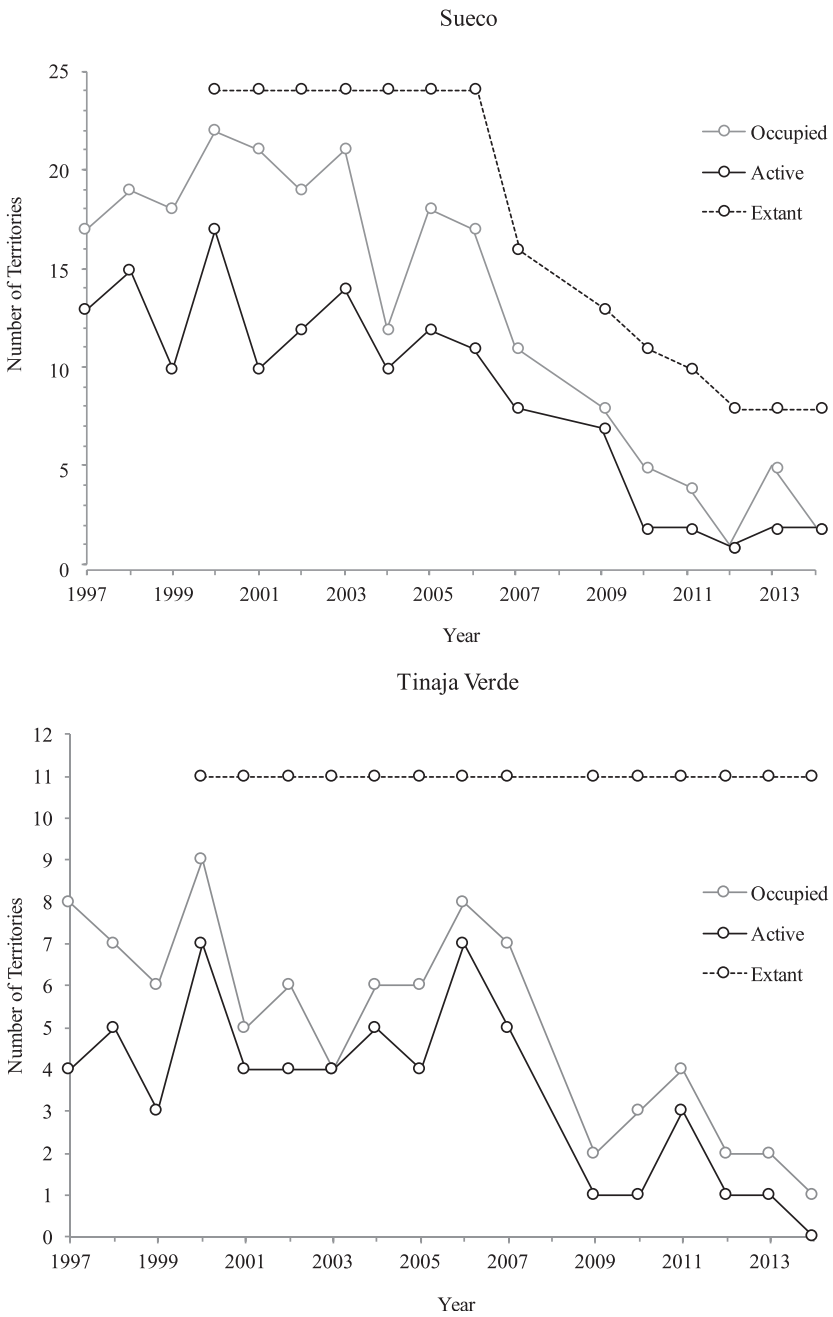


Figure 2. Trends in occupancy of historical Aplomado Falcon breeding territories and in the numbers of breeding pairs from 1997 to 2014 at Sueco (upper) and Tinaja Verde (lower) study areas in desert grasslands of central Chihuahua, Mexico. Data from 1997–2002 taken from Macías-Duarte et al. (2004). Extant territories were those occupied at least once during the study period and not yet destroyed by farmland conversion.

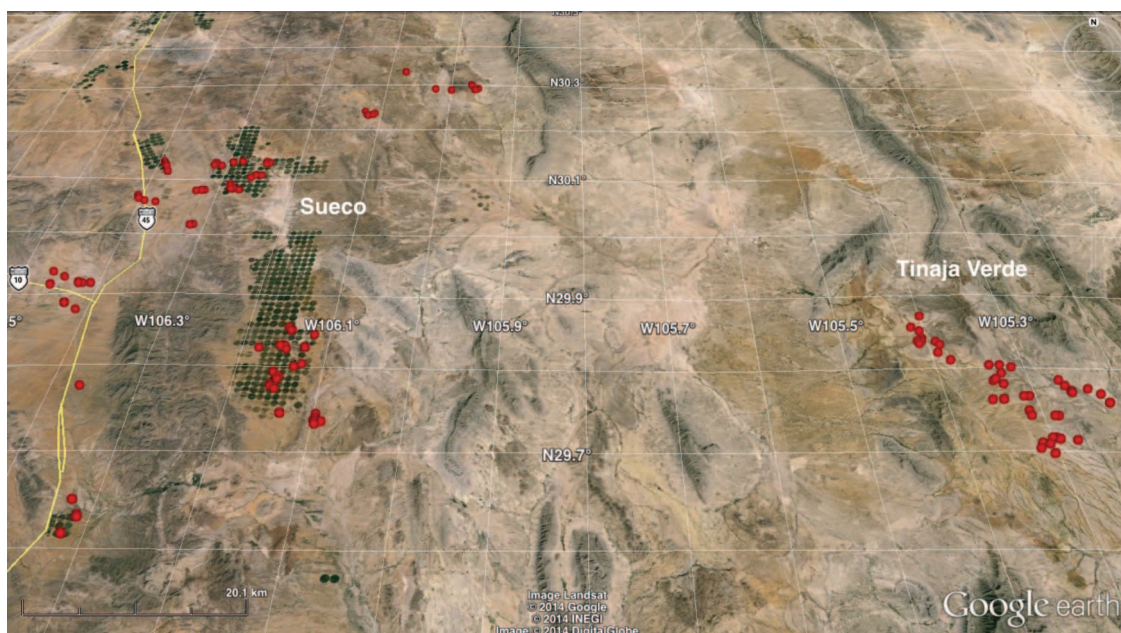


Figure 3. Spatial distribution of Aplomado Falcon nesting attempts (red dots) during 1997 to 2014 in the Sueco and Tinaja Verde study areas (see Macías-Duarte et al. 2004). The natural grasslands composing 17 breeding territories were converted to 800-m-diameter central-pivot irrigation agricultural plots (green circles) beginning in 2006. Numbers following the letters N and W denote latitude and longitude in decimal degrees, respectively.

The contribution of habitat destruction by irrigation farming to the overall population decline was confounded by the fact that the Sueco and Tinaja Verde study areas showed similar declining trends, although habitat destruction occurred only at Sueco (Fig. 3). There were also differences in habitat quality between Sueco and Tinaja Verde prior to the farming; Sueco had more breeding pairs and higher reproductive success, possibly as a consequence of higher prey occupancy and abundance (Macías-Duarte et al. 2004, 2009). Conversion of grasslands to farmland at Sueco thus appears to have destroyed higher quality falcon habitat with a presumably higher intrinsic capacity to buffer the effect of drought on falcon reproductive success. The lack of breeding activity at Tinaja Verde in 2014, however, suggests that, in addition to habitat loss, Aplomado Falcons in Chihuahua are facing ecological processes—most obviously, drought-related—with generalized effects upon habitat quality, processes that appear to have also prevented the success of the reintroduction of aplomados to southern New Mexico and west Texas (Hunt et al. 2013). We cannot yet be certain whether the cause of low occupancy at Tinaja Verde is lack of breeder recruitment or the inadequacy of territories to sustain occupancy during the period of survey (i.e., falcons becoming non-territorial). However, the effects of 20 yr of frequent and intense droughts (Macías-Duarte et al. 2004, Hunt et al. 2013, Reyes-Gomez et al. 2013) upon fecundity and therefore recruitment suggest the former. In addition, low observed recruitment of

falcons banded as nestlings (A. Macías-Duarte unpubl. data) suggests high juvenile mortality in the population.

Thus, it would appear that Aplomado Falcon populations in Chihuahua currently persist through high adult survival (“storage effect,” Warner and Chesson 1985); that is, individuals are “stored” in the adult population and are capable of contributing to reproduction when favorable conditions return. In support of this, we found five active nests during the 2015 breeding season after the rainy fall of 2014 and winter of 2015 that produced unusually lush conditions during the breeding season of 2015. However, long-term viability of any population subsisting through high adult survival requires some frequency of favorable conditions for reproduction. Climate change predictions for the region, however, discourage optimism, and the conversion of desert grasslands to croplands appears ongoing despite the protection the Aplomado Falcon should receive as a threatened species under NOM-059-ECOL-2010 (Anonymous 2010) and through conservation of its habitat under Mexican Forestry Law. Conservation measures might include (1) prey base augmentation, e.g., grain stations for doves, (2) modification of livestock watering tanks to reduce drowning risk, (3) power-line retrofits to reduce electrocutions, (4) agricultural use of only bird-safe pesticides and other chemicals, (5) restoration of tree-yucca (*Yucca elata* and *Y. torreyi*) populations optimal for nesting (Hunt et al. 2013), and (6) the provision of barred nest-boxes where natural nest structures are unavailable (see Hunt et al. 2013). These



Figure 4. Aplomado Falcon nest adjacent to farmland in Chihuahua, Mexico (photograph by J.R. Rodríguez-Salazar).

and other management practices are worthy of immediate consideration in view of the predicted negative consequence of inaction.

Given that breeding success is intrinsically linked with summer precipitation, however, climate-change-related drought may nevertheless preclude the recovery of Aplomado Falcons in the Chihuahuan Desert. Ironically, the farmers, by bringing water to the surface for irrigation, might, under the right circumstances, increase prey numbers; e.g., doves, even to the point of sustaining local pairs of Aplomado Falcons. There is little current evidence of such a possibility, however, except in the case of the only successful nest in 2014, a formerly occupied territory adjacent to farmland (Fig. 4). Perhaps not coincidentally, the only other productive site reported in the Chihuahuan Desert in 2014 was just north of the border in New Mexico, ca. 7.2 km from agricultural fields. In addition, two of the five nests found in 2015 were in the vicinity of farmland. It is thus conceivable that, if agricultural practices could maintain chemically safe prey populations year-round, and some of the other measures listed above were implemented, aplomado pairs in Chihuahua might reproduce even in periods of low precipitation. Chemically safe farming in Chihuahua might also promote the survival of juveniles during the post-fledgling dependence period and even nonbreeding

aplomados during drought. A telemetry study of two juveniles in 2015 showed they predominantly used recently opened agricultural areas (Fig. 3), after leaving their natal territories in native grasslands (A. Macías-Duarte unpubl. data). Lastly, the only documented sighting of an aplomado in west Texas in the decades preceding the release program was of an adult frequenting an irrigated field near the town of Valentine during January–May 1992 (Haynie 1994).

#### DESAPARICIÓN INMINENTE DE *FALCO FEMORALIS* DEL DESIERTO CHIHUAHUENSE

RESUMEN.—Seguimos la ocupación territorial de *Falco femoralis* durante un periodo de 12 años (2003–2014) en el centro de Chihuahua, México, bajo condiciones de sequía severa y destrucción de su hábitat de anidamiento. La conversión de los territorios de cría de los halcones a tierras agrícolas ha destruido hasta ahora 17 de los 35 territorios de cría ocupados por parejas de *F. femoralis* conocidos al menos una vez desde el año 2000. Sólo una pequeña fracción territorio de los restantes fue ocupada en 2014. La desaparición de los halcones de los territorios de cría antiguos que se mantienen intactos sugiere un déficit de reclutamiento causado por tasas reproductivas

bajas relacionadas con una disminución general en la calidad de los pastizales y en la cantidad de presas. La persistencia de unas pocas parejas sugiere que la población se mantiene actualmente por la elevada supervivencia de los adultos más que por su fertilidad. Esta tendencia, así como la continua destrucción del escaso hábitat de alta calidad para *F. femoralis* en Chihuahua y el norte de México, pronostican la desaparición de esta población de *F. femoralis* que habita en el desierto.

[Traducción del equipo editorial]

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